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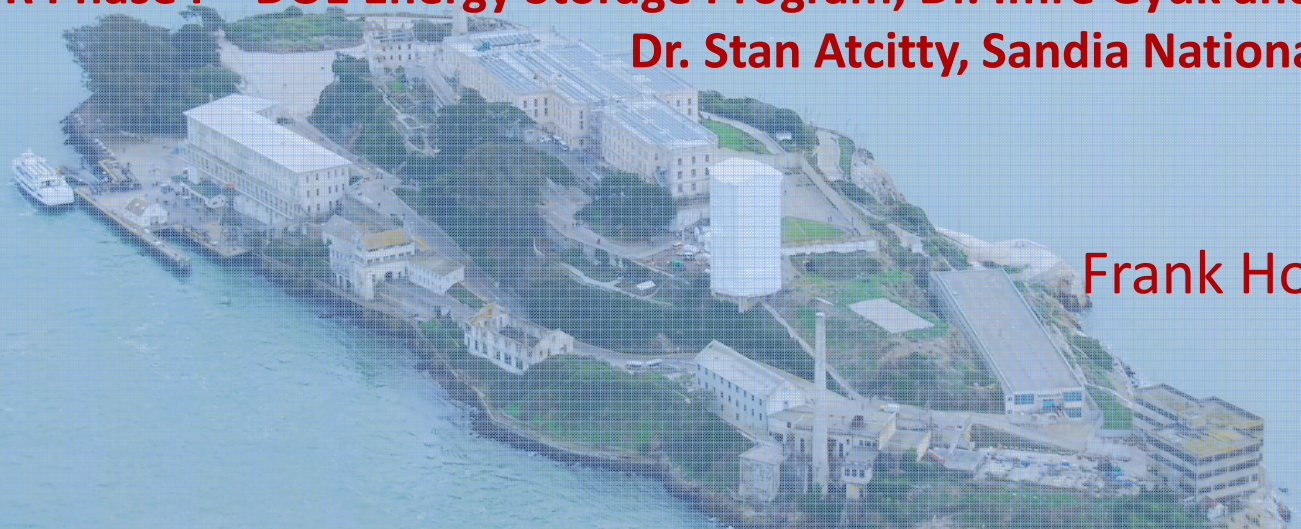
2014 DOE OE Energy Storage Program Peer Review

60kW Inverter with Built-In Isolation Using GaN Devices

(SBIR Phase I – DOE Energy Storage Program, Dr. Imre Gyuk and Technical POC Dr. Stan Atcitty, Sandia National Laboratories)



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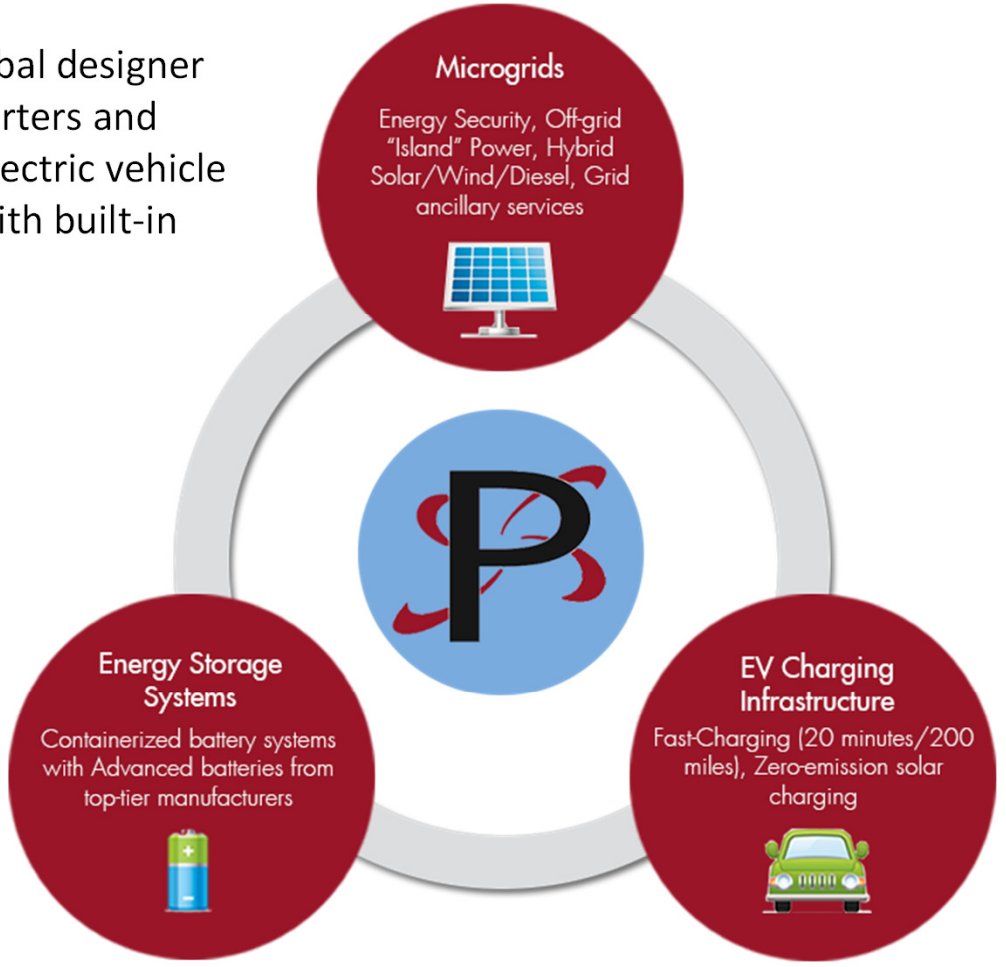
Project Team: PPS

Princeton Power Systems is a leading global designer and manufacturer of bi-directional converters and energy storage systems for microgrids, electric vehicle (EV) charging, and advanced batteries, with built-in functions for Smart Grid Services.



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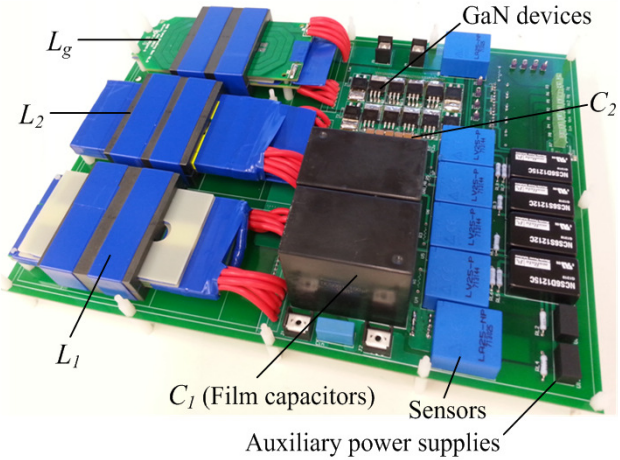
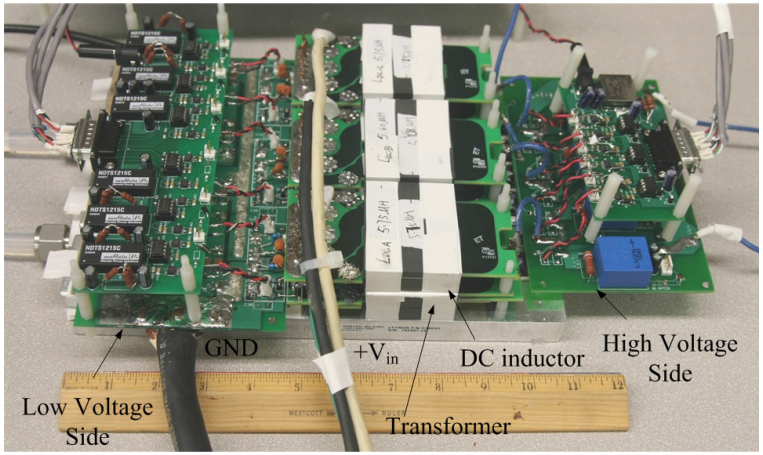
Project Team: Florida State University/PE Group

FSU/PE group has rich experience about WBG devices application in grid-connected PV converters. The group has successfully developed GaN based PV Module-Integrated Converter (MIC) and SiC based high power PV converters for grid-interactive application to achieve high power density and high power efficiency. The high frequency operation performance of GaN and SiC devices has been investigated and evaluated.



GaN based Module-integrated PV converter



Three-port 5kW grid-tie PV converter

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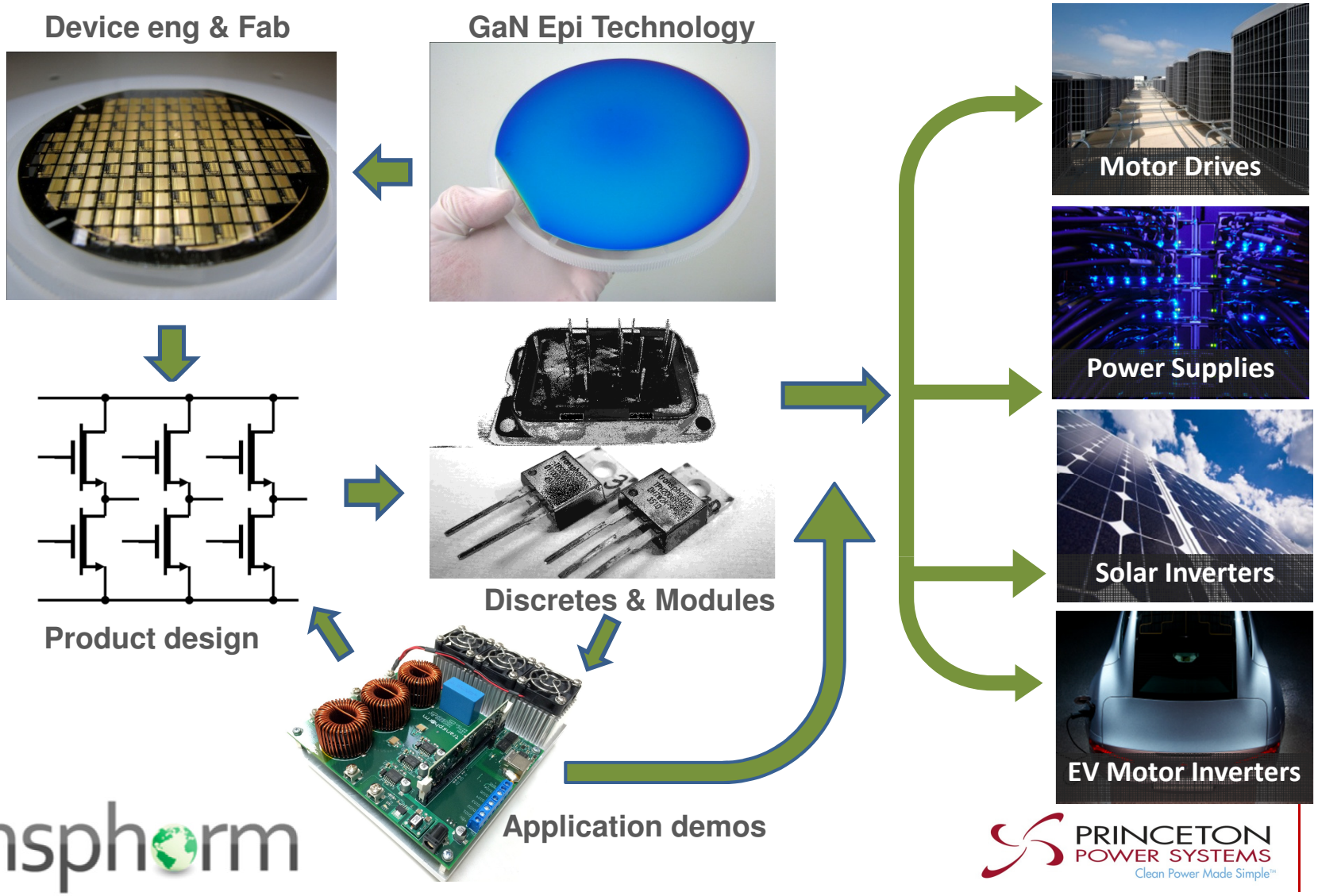
Project Team: Transphorm – GaN Technology



transphorm

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Why are we doing this ?

- **Technology Development:**
  - Demonstrate use of Wide-band-gap devices in a real application
  - Devices need to be used to become cheaper

Device need to become cheaper to be used

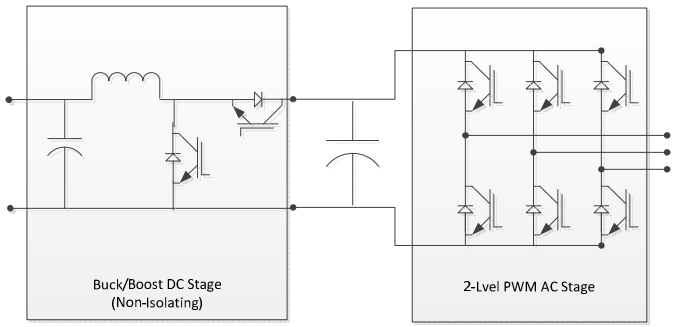
- **Product / Application Development**
  - Reduce cost & size of grid-tied energy storage installations by eliminating bulky grid-side isolation transformers
  - Improve efficiency
  - Reduce noise (by switching at frequencies outside the audible range)

Project Steps

- **Phase I : Design 60kW inverter for grid-tied storage applications**
  - **Base design on existing PPS 100kW inverter**
  - **Incorporate DC side isolation by using Dual-Active-Bridges (DAB) using GaN devices**
  - **Demonstrate DAB functionality**
- **Phase II : Build prototype inverter**
  - **Modify an existing GTIB inverter with design from Phase I**
  - **Demonstrate inverter functionality**

PPS Grid-Tied Inverter (GTIB-100)

- 100kW grid-tied inverter
  - Buck/boost DC stage
  - 2-level PWM AC stage
  - 6.5kHz switching frequency
- Proven technology, used in a number of grid-tied energy storage applications
  - 'Two-Ups' for Tesla
  - WPD project with GE in the UK
- No internal isolation -> typically requires external transformer



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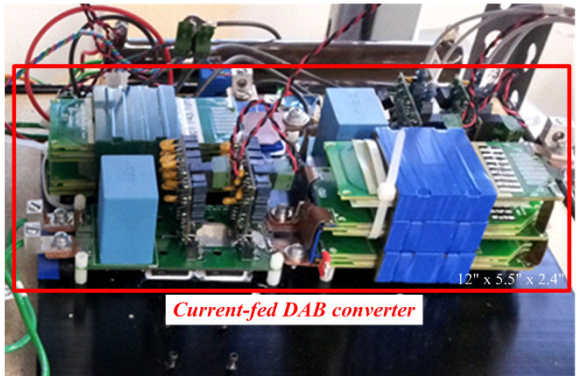
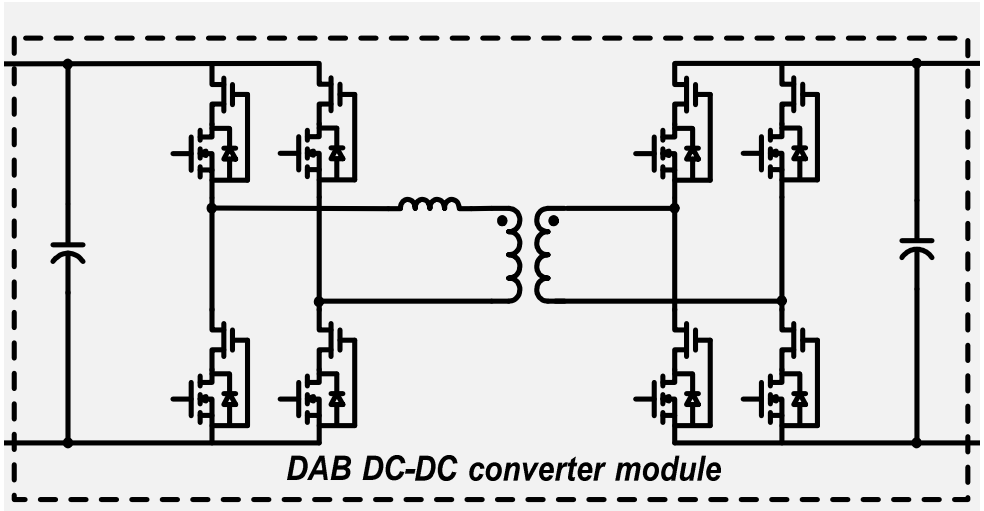
Dual-Active Bridge DC-DC Converter (FSU)

- **High-frequency switching (proven in lab at FSU)**
  - **Drastically decreases size of DC port components**
- **Built-in galvanic isolation**
  - **Eliminates grid-side transformer, increasing overall system power density**





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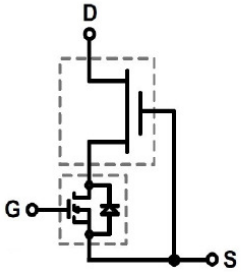
High Voltage GaN HEMT

- High Switching Frequency : 10x of Si devices for smaller Q_g, C_{oss} & Q_{rr}
- Low R_{ds_on}: V_B^2/R_{on}=5000 (40 for Si)
- High temperature operation > 200 C
- Third quadrant operation: Eliminates free-wheeling diode
- Normally-off operation: Safe for high voltage/power



TO-220 Package

Ron	Vds,max	Imax(pulse)	Imax(CW)
mohm	V	A	A
30	*900*	*240*	*70*
Rth	Qg	Qoss	Qrr
°C/W	nC	nC	uC
0.2	*25*	*320*	*0.35*
*Per switch			

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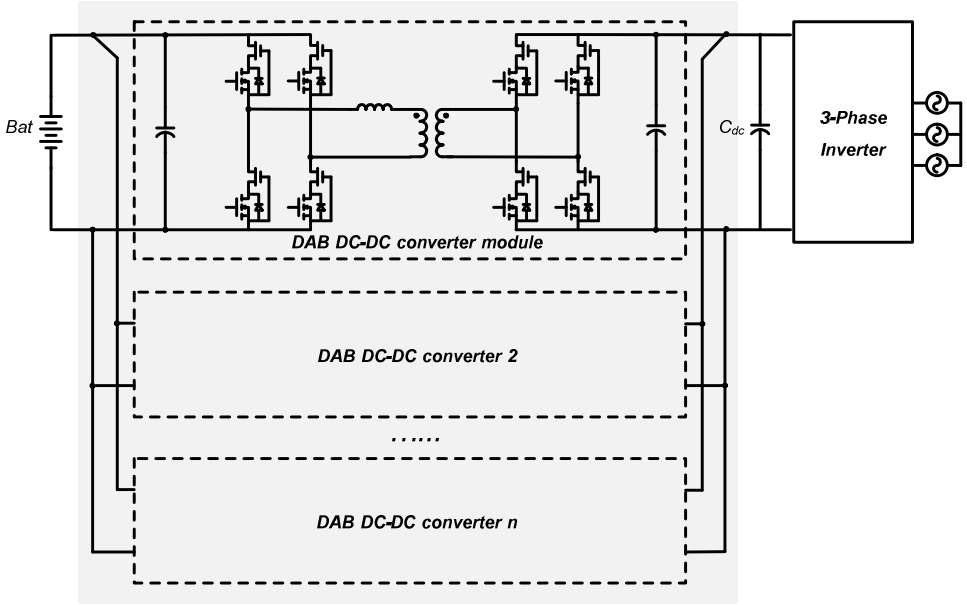
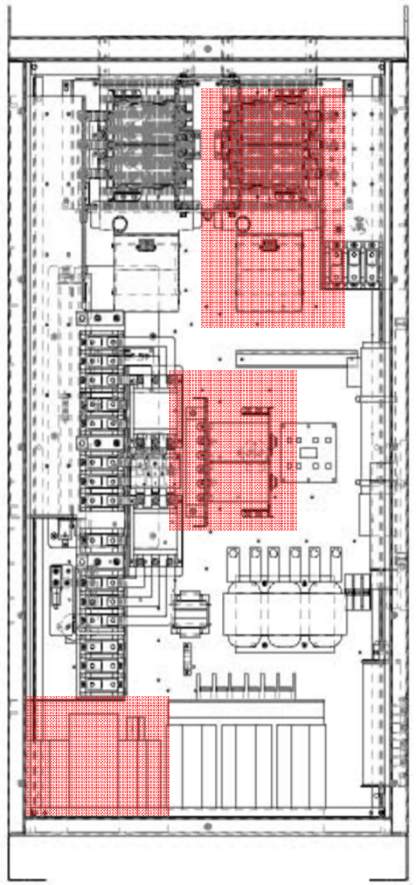
Target System Architecture

- Keep existing AC stage of GTIB inverter
  - Focusing on main project aspect
- DC stage will consist of multiple DAB converters
  - Allows interleaving, to reduce current ripple
  - Avoids challenges from having to parallel GaN devices



Design Goals

- DC-DC Stage Efficiency >= 98%
- Increase overall power density of installation by 40%
- Reduce overall system cost by 20%
  - Eliminate grid-side isolation transformer (-20% total system cost)
  - Reduce cost of reactive components for DC side by estimated 50% (-6% total system cost)



Removable DC port Components

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Dr. Stan Atcitty for his technical contributions.

Thank you

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